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PHILADELPHIA, PENNSYLVANIA

AEROSPACE CREW EQUIPMENT LABORATORY

PROBLEM ASSIGNMENT NO. C04AE13-6
PART 2
ANALYSIS OF ANTHROPOMETRIC DATA ON NAVAL AVIATORS

The Integrated Anthropometric Device
in Naval Aviation

NAEC-ACEL-508 29 JANUARY 1964

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ABSTRACT

The compatibility and accommodation of aircrew personnel in modern high performance aircraft and space vehicles have been seriously handicapped by a lack of specific and detailed morphological measurements. A device has been designed by which inexperienced personnel may obtain rapid and accurate measurements in a continuing anthropometric survey program. The design criteria and the subsequent development of the device is discussed. The results of experimental evaluations of the reliability and accuracy of the device, when employed by naval medical technicians, are presented.

INTRODUCTION

Valid anthropometric data are essential to the proper design of inhabited spaces aboard airborne and space vehicles. In addition, they are important in determining control location and display configurations, design of escape systems, and sizing and design of personal protective and safety equipment and clothing. Traditional methods of gathering anthropometric data require the use of relatively complex instruments manipulated by skilled operators. This report describes a simply constructed device for obtaining certain critical body measurements which can be used by relatively inexperienced personnel on a regular basis to obtain accurate anthropometric data on aircrewmen.

PROBLEM

The traditional techniques for obtaining anthropometric data require skilled personnel who have been trained in physical anthropology methods. The techniques, when used by skilled personnel, give reliable and valid data. The instruments are cumbersome to use and the scales can be easily misread since, in most instances, the measurer is required to keep them in the correct position while taking a scale reading. The measurer also must have a thorough knowledge of the various body "points" where the measurements are to be taken. Thus the data obtained is only as accurate and reliable as the measurer.

A new technique, and the means to put the technique into effective operation in a continuing program had to be evolved to meet the needs of naval aviation. The problem of obtaining accurate measurements is based primarily on two factors: (1) the type of equipment and instruments to be employed and (2) the availability of personnel experienced and skilled in making such measurements with the necessary high degree of accuracy. The need also exists to obtain this data fairly continuously so that the various ranges of the population to be accommodated are constantly being analyzed and adjusted. These factors were considered as a basis for the design of a suitable technique and measuring equipment, employing relatively inexperienced personnel with a minimum of training and instruction. The combination of simplicity, accuracy, and ease of use is the prime requisite in establishing design criteria.

DESIGN

The Integrated Anthropometric Device, Figures 1 through 7, is a result of the application of criteria of simplicity, accuracy, and ease of use. To acquire the desired degree of simplicity in this device, the number and type of measurements to be taken is necessarily limited. The device is designed to obtain seven measurements, in the following order: (1) height, (2) functional arm reach, (3) sitting height, (4) shoulder width, (5) trunk height, (6) buttock-knee length, and (7) buttock-leg length. The measuring components are integrated into a single device which allows the subject to be measured without constant repositioning, a process which reduces the overall accuracy of the measurements. It is considered that provision for making more than the above measurements would tend to

make the device too complex for inexperienced personnel to operate accurately without extensive instruction and training.

Selection of materials and type and scope of machine operations to be performed in the fabrication process influenced the overall design to a great extent. The device was so designed as to enable various Naval air activities to fabricate and construct it from materials readily available, with a minimum of machining operations.

The basic structure is made of three-quarter inch plywood in a rigid configuration. With the exception of one stainless steel scale and the teflon bases of two measuring means, the remaining scales and measuring means are fabricated of aluminum and quarter inch plexiglas.

The ease of operation of the device is insured by one of its main features - the measuring means are always in the same relative position on the device and can be readily moved to mark off the dimensions of a subject. Using traditional methods, the measurer has to judge whether the instruments are in the correct position and must maintain such a position while taking scale readings. With the Integrated Anthropometric Device, the measurer is primarily concerned with the correct positioning of the subject in the device to insure accurate and reliable data collection. Since the measurer operates a single, integrated device, rather than several individual instruments, greater accuracy of the data is more likely to be obtained.

TEST

A prototype model of the device was constructed and subjected to an evaluation, under simulated operating conditions, by a team of naval enlisted medical personnel supervised by a flight surgeon. The flight surgeon was responsible for giving instructions and supervising the actual collection of data. The entire evaluation was under the close observation of professional personnel who have had extensive experience in anthropometric techniques.

Eight hospital corpsmen inexperienced in the use of the device were employed as the measurers, and each corpsman measured the same eight subjects. Seven measurements, six made with the device and the subject's weight, were obtained and the results statistically analyzed. Of the seven measurements taken, only six were included in the analysis, weight being excluded. The results are given in Table I. Functional arm reach was not included at this time since the measuring means for this dimension had not yet been incorporated into the device.

The average deviation indicates how closely the eight measurers agree on their measurements of the eight subjects. The smaller the average deviation, the more closely the measurers are in agreement. It should be noted that these values are only measures of the statistical accuracy of the use of the device, not a direct measure of the accuracy of the device itself. It is considered that if the average deviations are about the same, or less than, the smallest increment on the measuring scales, 0.1 inch, the degree of accuracy of the device is acceptable. Because the average deviations for height,

trunk height, and buttock-leg length were significantly greater than the measuring scale accuracy of 0.1 inch, modifications to the measuring means and the techniques to increase the accuracy of these measurements were necessary. Appropriate redesign of the device and procedures was accomplished to correct these deficiencies. A second evaluation was conducted by three measurers and eight subjects. The results of this analysis appear in Table II. In this second evaluation the statistical accuracy of these three measurements is well below the scale accuracy of the device. Thus, it was considered that the device has the necessary degree of accuracy to obtain reliable anthropometric data.

On the basis of the results obtained, it is suggested that two persons should be employed in the measuring process in order to facilitate the collection of reliable data, one person acting as the measurer and the other as recorder. Maximum care should be exercised in correctly positioning the subject's body. The instructions, Appendix A, should be thoroughly read and understood prior to starting the measuring process and these instructions should be strictly followed.

A limited field evaluation has been undertaken at several naval aviation activities to ascertain the suitability of the device for their operational use. The results have proved, thus far, to be satisfactory from a data collection viewpoint. Incorporation of the device into existing aviation medical facilities poses no problems.

A special data collection form, illustrated in Figure 8, was designed for use with the device.

CONCLUSIONS

As a result of the laboratory and field evaluations, the Integrated Anthropometric Device is considered to be satisfactory for its intended purpose, the collection of anthropometric data on the naval pilot population. The device is suitable for construction and location at all naval aviation activities, both ashore and afloat, thus providing a prime source of anthropometric data readily available for analysis, on a continuing basis, and capable of reflecting changes in the naval pilot population. This continuing analysis should provide a basis for the establishment of up-to-date criteria affecting cockpit and aircrew workspace design.

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TABLE I

FIRST EVALUATION OF INTEGRATED ANTHROPOMETRIC DEVICE

Measurement	Average Deviation (inch)
Height	0.167
Sitting Height	0.054
Shoulder Width (Bideltoid)	0.117
Trunk Height (Acromial, sitting)	0.275
Buttock-knee Length	0.084
Buttock-leg Length	0.175

TABLE II

SECOND EVALUATION OF INTEGRATED ANTHROPOMETRIC DEVICE

Measurement	Average Deviation (inch)
Height	0.020
Trunk Height (Acromial, sitting)	0.077
Buttock-leg Length	0.020

APPENDIX A

INSTRUCTIONS FOR USE OF INTEGRATED ANTHROPOMETRIC DEVICE

The Integrated Anthropometric Device is designed to obtain seven (7) morphological measurements accurately and with relative ease. All the measurements must be made with the subject wearing undershorts only. All dimensions should be read to the nearest graduation mark, 0.1 (1/10) inch. The measurements, and the order in which they are taken, are:

1. Height
2. Functional Arm Reach
3. Sitting Height
4. Shoulder Width
5. Trunk Height
6. Buttock-knee Length
7. Buttock-leg Length

1. Height: Fig. 1 - The subject stands erect with his back, shoulders, and feet firmly positioned against the back of the device. The measurer moves the measuring probe until it touches the scalp firmly. The measurer reads the scale, noting the dimension marked by the bottom edge of the probe pointer.

2. Functional Arm Reach: Fig. 2 - The subject stands erect with his back, shoulders, and feet firmly positioned against the back of the device, with the left shoulder aligned as closely as possible with the measuring probe. The measurer loosens the wing nut, moves the probe until the plastic plate makes contact with the top of the subject's left shoulder, and then tightens the wing nut. The subject grips the metal tab at the end of the steel tape between his thumb and forefinger, with the thumb and forefinger firmly positioned horizontally against the metal tab end, and moves his left arm out, horizontally, away from the back of the device. The measurer reads the dimension marked by the black scale marker and reads to the nearest graduation mark on the steel tape, 0.1 (1/10) inch.

3. Sitting Height: Fig. 3 - The subject sits erect, looking directly forward, with his head, shoulders, back, and buttocks firmly positioned against the back of the seat and centered directly beneath the measuring probe with his feet resting on the floor of the platform so that his knees are bent at approximately right angles. The measurer should stand directly facing the subject and move the measuring probe until the flat surface of the probe makes contact with the highest surface on the subject's head. The measurer reads the scale to the left of the probe, noting the dimension marked by the bottom edge of the probe pointer.

4. Shoulder Width: Fig. 4 - The subject remains seated as for the Sitting Height measurement. He sits with his upper arms hanging at his sides and forearms extended horizontally forward. The measurer stands directly facing the subject and moves the left probe (measurer's left) inboard until it gently touches the maximum lateral surface protrusion of the subject's right arm (deltoid muscle). The measurer then moves the right probe (measurer's right) inboard until it gently touches the maximum lateral surface protrusion (deltoid muscle) of the subject's left arm. The measurer reads the scale through the view port in the right probe noting the dimension marked by the engraved marker.

5. Trunk Height: Fig. 5 - The subject remains seated in the Sitting Height position. The responsible medical officer should locate the right acromion and place a grease pencil marking, or other suitable marking, on the subject's skin at this point to aid in the measurement. The measurer stands directly facing the subject and moves the sliding scale, up or down as required, and the extension arm until the bottom of the extension arm touches the right acromion (skin marking). The measurer reads the scale noting the dimension marked by the engraved markers on the scale channel.

6. Buttock-knee Length: Fig. 6 - The subject remains in the Sitting Height position. His right leg should be bent back so that the bony protuberance below the knee cap does not interfere with the probe. The measurer swivels the probe into position and locks it in place by inserting the ring pin and then moves the slide until the face plate is firmly positioned against the knee cap. The measurer reads the scale noting the dimension marked by the scale marker slot in the scale channel. After the measurement is taken the ring pin must be removed and the face plate swivelled out of the way to allow for the next measurement.

7. Buttock-leg Length: Fig. 7 - The subject remains in the Sitting Height position. The subject extends his right leg as far as possible on the leg bench. The measurer stands to the left of the leg bench and moves the probe until the flat surface makes contact with the subject's heel. The measurer reads the scale noting the dimension marked by the bottom edge of the probe pointer.

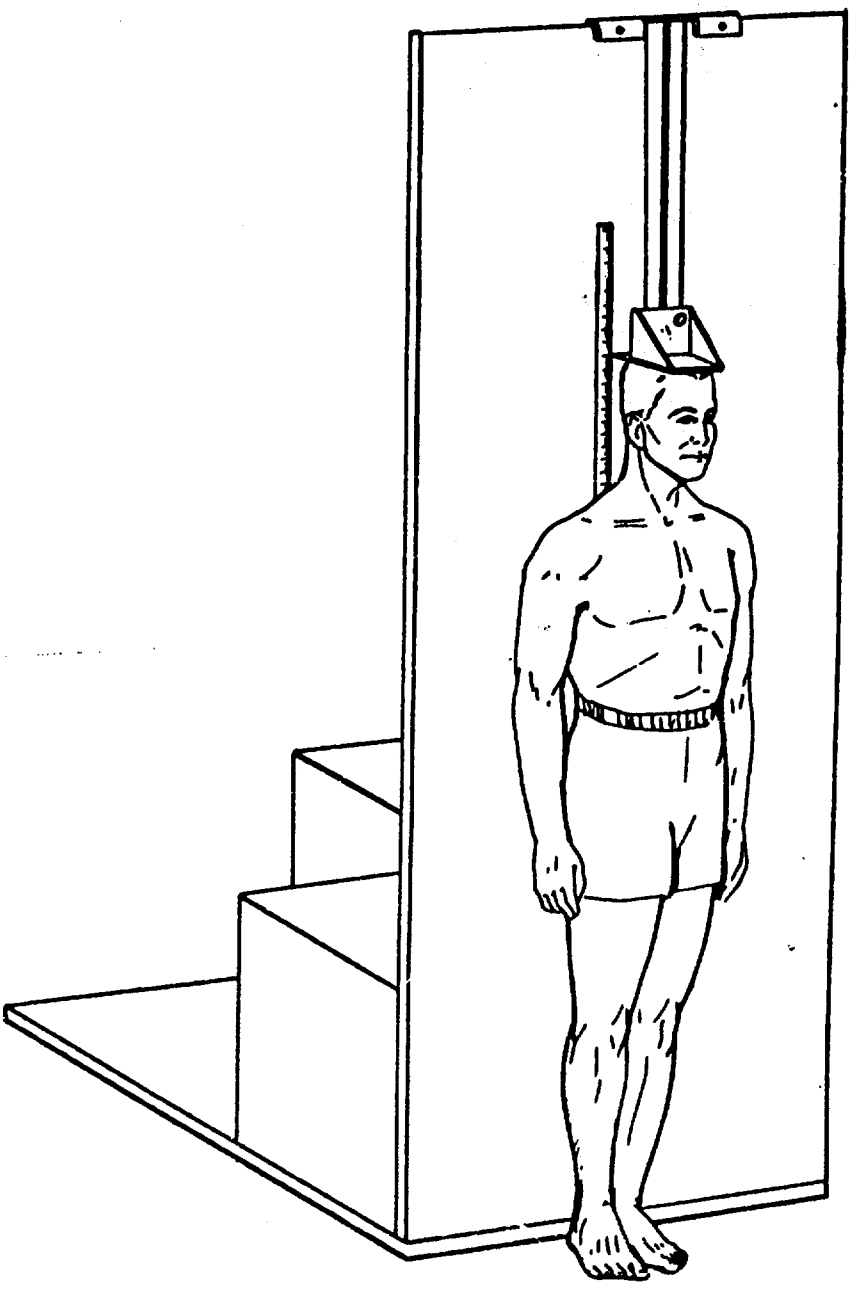

FIGURE 1

Height

FIGURE 2

Functional Reach

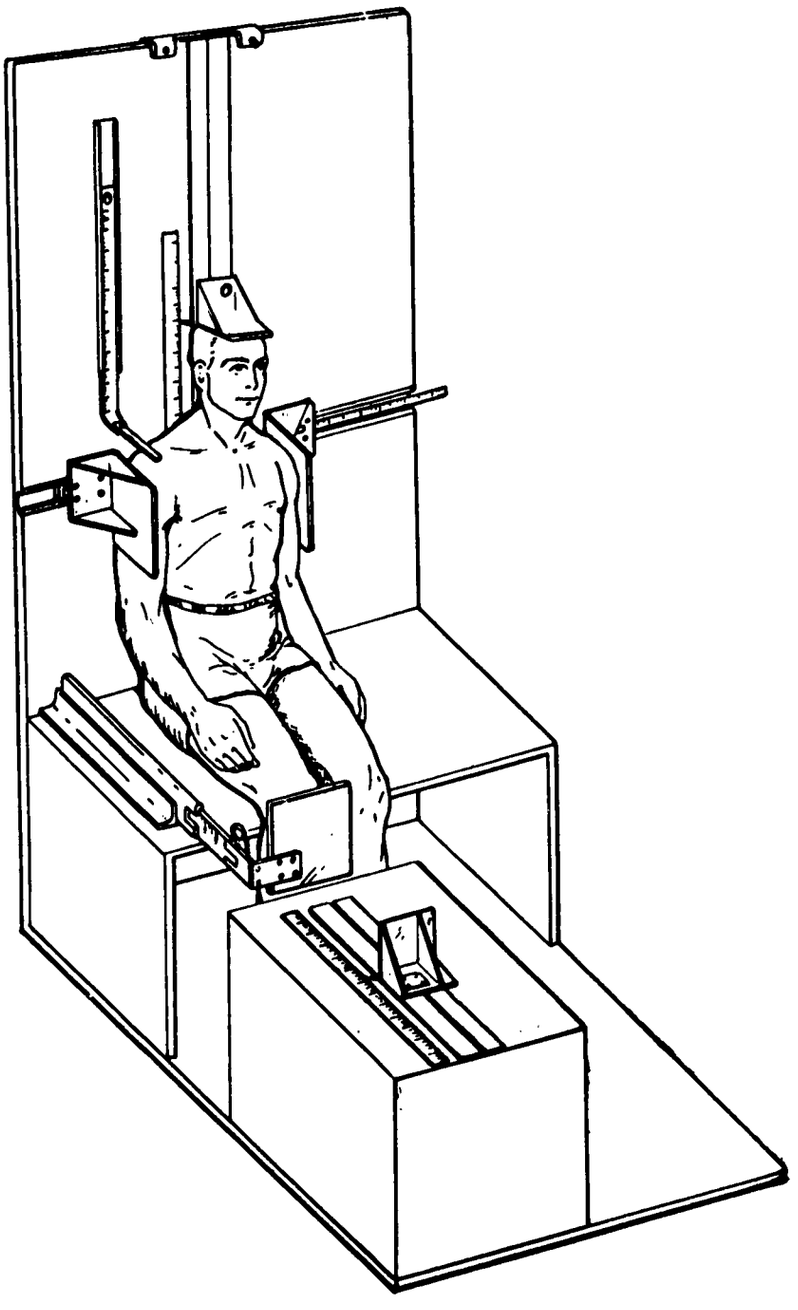

FIGURE 3

Sitting Measurements

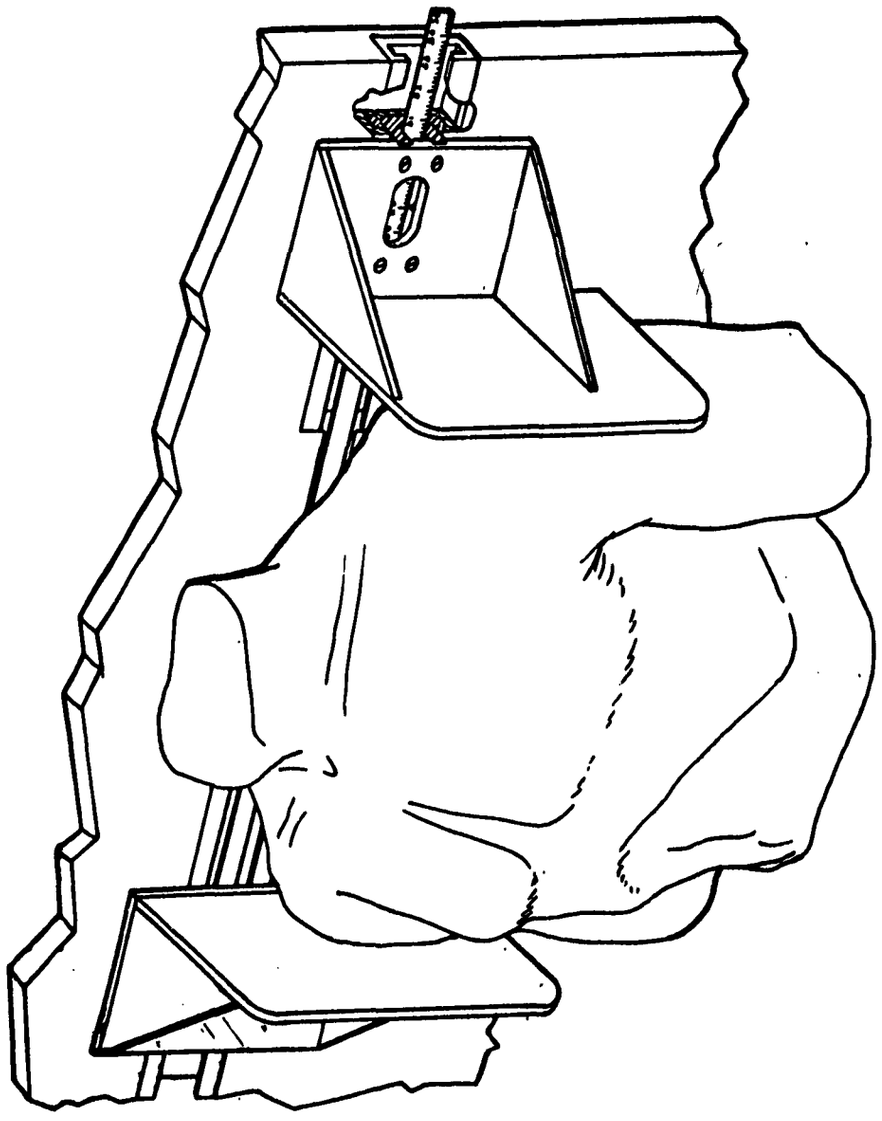

FIGURE 4

Shoulder Width

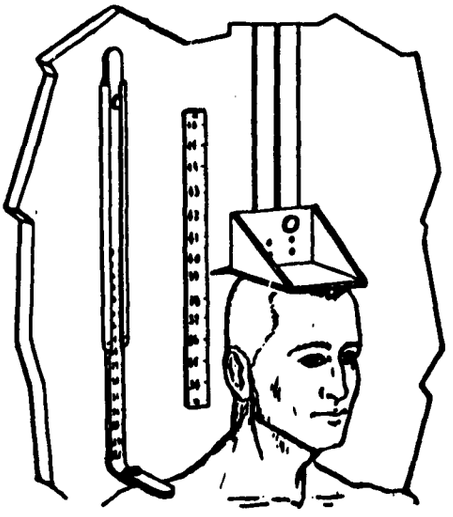

FIGURE 5

Sitting Height

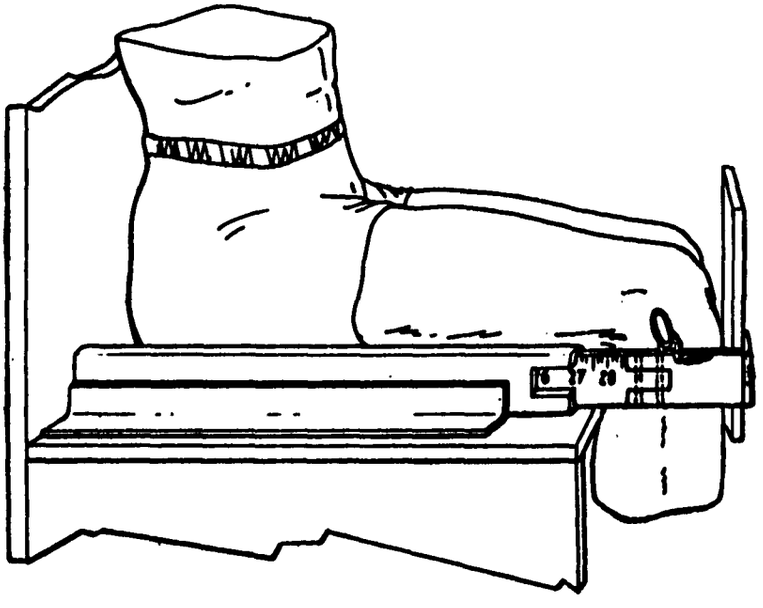

FIGURE 6

Buttock-knee Length

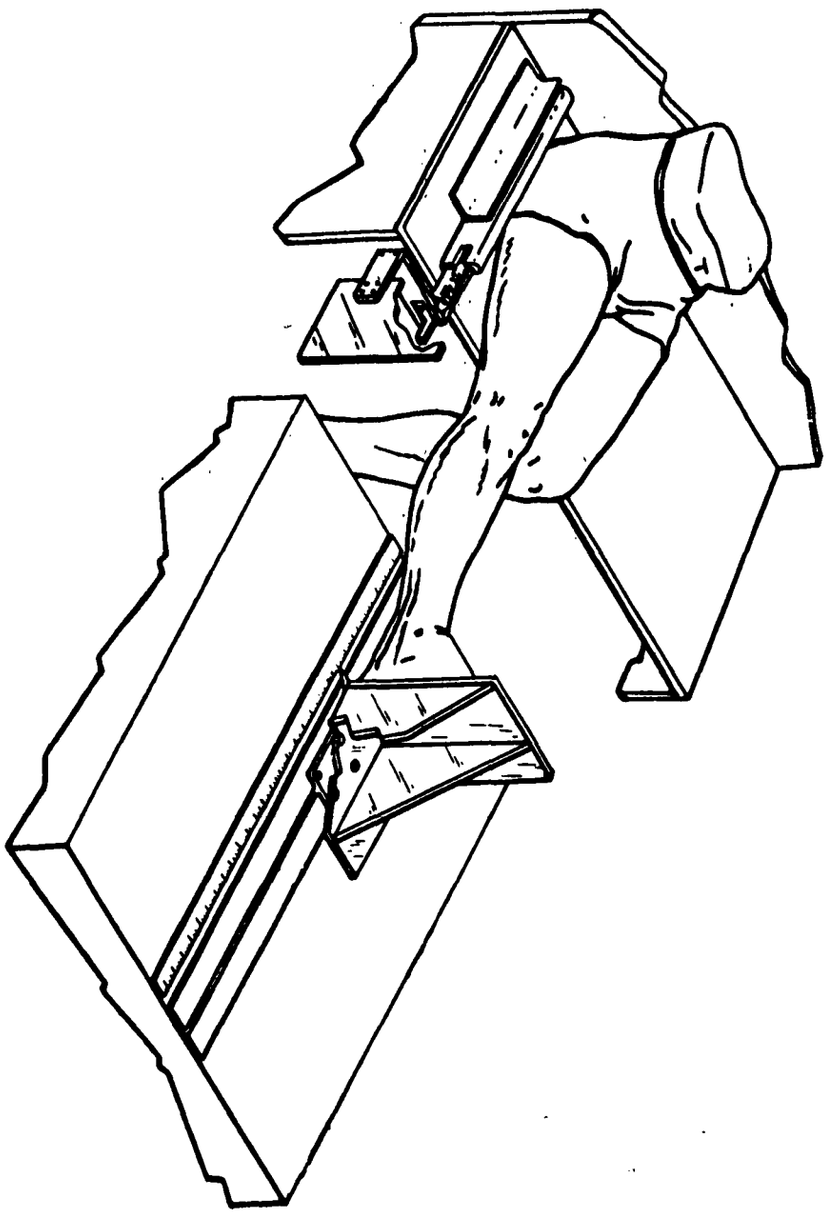

FIGURE 7

Buttock-leg Length

ANTHROPOMETRIC DATA FORM
4ND-NAEC-6150/1 REV 3-63 PRINT OR TYPE PLAINLY

NAME (last, first, and middle initial)				SERIAL NUMBER
RANK	AGE	TYPE AIRCRAFT PRESENTLY FLYING	DATE OF EXAM.	ACTIVITY CONDUCTING EXAMINATION

(1) _____ Pounds - WEIGHT

(2) _____ Inches - HEIGHT

(3) _____ Inches - SITTING HEIGHT

(4) _____ Inches - SHOULDER WIDTH

(5) _____ Inches - TRUNK HEIGHT

(6) _____ Inches - BUTTOCK-KNEE LENGTH

(7) _____ Inches - LEG LENGTH

(8) _____ Inches - FUNCTIONAL REACH

MEASUREMENT DEFINITIONS

WEIGHT - Taken to nearest pound on standard scales, with subject in underwear.
HEIGHT - Vertical distance from floor to top of head with subject standing erect.
SITTING HEIGHT - Vertical distance from seat surface to top of head with subject sitting erect.
SHOULDER WIDTH - Distance across shoulders between greatest protrusion of deltoid muscles.
TRUNK HEIGHT - Vertical distance from seat surface to right shoulder with subject sitting erect.
BUTTOCK-KNEE LENGTH - Distance from back of right buttock to front of kneecap with subject sitting erect.
LEG LENGTH - Distance from back of right buttock to heel of foot with subject sitting erect.
FUNCTIONAL REACH - Horizontal distance from back of right shoulder to tips of thumb and forefinger pressed together.

SIGNATURE (Medical Officer/Flight Surgeon)

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FIGURE 8

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ANALYSIS OF ANTHROPOMETRIC DATA ON NAVAL AVIATORS
The Integrated Anthropometric Device in Naval Aviation; by J. R. Provost and E. C. Gifford, 29 Jan 1964, 12 p., 8 figs., 1 App.

1. NAEC-ACEL-508
2. Problem Assignment No. C04AE13 6, Part 2
3. In DDC collection

The compatibility and accommodation of aircrew personnel in modern high performance aircraft and space vehicles have been seriously handicapped by a lack of specific and detailed morphological measurements. A device has been designed by which inexperienced personnel may obtain rapid and accurate measurements in a continuing anthropometric survey program. The design criteria and the subsequent development of the device is discussed. The results of experimental evaluations of the reliability and accuracy of the device, when employed by naval medical technicians, are presented.

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